

**PROGRAM PLAN**

**FOR FISCAL YEARS  
2000 THROUGH 2004**

**INDUSTRIAL MATERIALS FOR THE FUTURE  
(IMF)**

**JULY 2000**

**U.S. DEPARTMENT OF ENERGY  
OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY  
OFFICE OF INDUSTRIAL TECHNOLOGIES**

## TABLE OF CONTENTS

<b>Executive Summary .....</b>	<b>i</b>
<b>1. Introduction .....</b>	<b>1</b>
<b>2. Strategic Issues .....</b>	<b>3</b>
<b>3. Program Mission, Goals, Strategies, and Performance Metrics .....</b>	<b>5</b>
<b>4. R&amp;D Plan — Fiscal Year 2000 through 2004 .....</b>	<b>7</b>
<b>5. Program Management Plan .....</b>	<b>9</b>

## EXECUTIVE SUMMARY

This multi-year program plan outlines the mission, goals, and strategies of the Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies (OIT) for conducting research and development (R&D) activities in *industrial materials*. The Office's *Industries of the Future (IOF)* process has shown that improved materials are a crosscutting need of many industries and one of the keys to cleaner and more energy-efficient and productive manufacturing. The nine industries on which OIT is focused (known as the "IOFs") are agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum, and steel. Supporting industries are forging, heat treating, welding, and carbon products.

Several programs within OIT currently conduct R&D projects in advanced industrial materials. The purpose of this plan is to outline a new approach for integrating these existing activities into a unified, comprehensive *Industrial Materials for the Future (IMF)* program. The plan calls for the integration of all of the Office's crosscutting efforts in advanced materials beginning in fiscal year 2000 and is planned through 2004. It is intended to address recent recommendations made by the National Research Council to sharpen the focus of materials research in OIT on industry-specific and crosscutting needs of the *IOFs* while at the same time maintaining appropriate efforts in certain "core" R&D areas.

### MISSION, GOALS, AND STRATEGY

Consistent with the mission of the OIT<sup>1</sup>, the *mission* of the new IMF program is to lead a national effort to research, design, develop, engineer, and test new and improved materials, as well as more profitable uses of existing materials, for the *IOFs*. There are, and will continue to be, projects supported by the IOF teams to address relatively short-term materials needs for the specific industries. If the materials technologies are of sufficient maturity to compete for funding from the IOF teams, they will not, in general, be supported by the IMF Program. Rather, the program will address longer-range needs of industry by supporting research and development that will need nurturing to reach the stage at which the technology can compete successfully for funding from the IOF teams, with emphasis on materials needs common to multiple *IOFs*.

The *strategy* of the IMF program is to identify, support, and nurture promising efforts in materials and processing technologies to the point that they can be demonstrated in industrial applications. The scope of funded activities will cover proof of concept, applied research and development, and applications engineering.

Activities will be conducted in three main areas:

- industry-specific technologies,
- crosscutting technologies, and
- knowledge base or core activities.

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<sup>1</sup> Office of Industrial Technologies. *Strategic Plan — A Work in Progress*. U.S. Department of Energy, Office of Energy Efficiency and Renewable Energy. August 1999.

In addition, the program will support directed activities such as studies by independent organizations, workshops, evaluations, and program planning and analysis. The relative mix of activities among these areas will be determined by OIT management and will evolve over the transition period in response to emerging *IOF* needs and new developments in crosscutting technologies. The initial targets are 50% funding for industry-specific and crosscutting technologies, 35% funding for core activities, and 15% funding for directed activities.

## TRANSITION TO A UNIFIED PROGRAM

The IMF program will take shape over a four-year transition period. This transition period is important because of contractual obligations to industrial participants in the Continuous Fiber Ceramic Composites Program and the need to ensure successful completion and commercialization of technologies addressed by current projects in the Advanced Industrial Materials Program.. Beginning in fiscal year 2000, an assessment of existing materials-related projects in the Office will be completed in order to determine the time and funding required to bring them to a successful conclusion. This assessment will be used for program planning through the transition period and will provide a starting point for a more comprehensive study by an independent organization to determine future directions and priorities for the IMF Program, based on a detailed examination of materials needs in the *IOFs*. The first stage will be completed by the end of the first quarter of FY 2001; the independent study may require a year or more. The groups conducting these studies will not make up a permanent advisory group for the Program.. A permanent advisory group will consist of a subset of the advisory group that will provide guidance and evaluation for the over-all OIT effort. The expected allocation of funding by type of activity (i.e., completion of R&D initiated prior to the creation of the IMF program, new projects selected under the IMF program, and directed activities) for the five-year period FY 2000 through FY 2004 is shown in the table below.

<b>Expected Allocation of Funding for Advanced Industrial Materials, 2000 - 2004 (Percent of Total Funding)</b>					
<b>Activity</b>	<b>2000</b>	<b>2001</b>	<b>2002</b>	<b>2003</b>	<b>2004</b>
<b>Completion of Pre-IMF R&amp;D</b>	88	60	35	10	0
<b>Support of New Projects Selected Under IMF<sup>a</sup></b>	11	25	50	75	85
<b>Directed Activities</b>	1	15	15	15	15
<b>TOTAL</b>	100	100	100	100	100

a Includes two competitive solicitations: one for industrial applicants (and their teaming partners) and one for the national laboratories and universities

# 1. INTRODUCTION

This multi-year program plan outlines the mission, goals, and strategies of the Department of Energy, Office of Energy Efficiency and Renewable Energy, Office of Industrial Technologies (OIT) for conducting research and development (R&D) activities in *industrial materials*. OIT's *Industries of the Future (IOF)* process has shown that improved materials are a critical need of many IOFs and one of the keys to cleaner and more energy efficient and productive manufacturing for U.S. companies over the next twenty years.

Several programs within OIT currently conduct R&D projects in advanced industrial materials. The purpose of this plan is to outline a new approach for integrating these existing activities into a unified, comprehensive *Industrial Materials for the Future (IMF)* program. The plan calls for the integration of all of the Office's crosscutting efforts in advanced materials beginning in fiscal year 2000 and is planned through 2004.

## INDUSTRIES OF THE FUTURE

The IMF program will enable the Office to sharpen the focus of its R&D in advanced industrial materials on the priorities of the *IOFs*. The *IOF* strategy involves the development and implementation of industry-driven visions and roadmaps. In its *Vision of the Future*, each industry establishes performance goals for the future, typically the year 2020. The industry then develops one or more *Technology Roadmaps* that identify the most critical areas of need for achieving the goals outlined in the vision. The Office participates in the implementation phase of the *IOF* process by cost sharing research, development, and demonstration (RD&D) projects on technologies that address needs identified in the roadmaps. The *IOF* teams work with their industrial counterparts to manage the RD&D, which is implemented primarily through competitive solicitations.

The *IOF* strategy has been used successfully since 1994 by a number of energy-intensive U.S. industries to determine near, mid, and long term technology needs for manufacturing and production in agriculture, aluminum, chemicals, forest products, glass, metal casting, mining, petroleum refining, and steel. Industries that supply crosscutting technologies and equipment to these nine industries have also benefitted from participation in the *IOF* process, and several (e.g., forging and heat treating) have subsequently developed their own visions and roadmaps.

As part of the vision and roadmapping process, literally hundreds of executives and technology experts from industry, state agencies, universities, national laboratories, and non-governmental organizations have met in dozens of workshops to discuss success factors for their industries in the global marketplace over the next twenty years. The resulting roadmaps document the extensive technological needs that have been identified, including many that can be addressed with better industrial materials. For example, several of the *IOFs* and crosscutting technology roadmaps identify the need for industrial materials that are corrosion resistant, tolerant of high-temperature and high-pressure environments, and capable of precision operations.

With regard to the Office's research programs in advanced industrial materials, a recent report by the National Research Council<sup>2</sup> recommended that the Office "...complete the transition to the *IOF* strategy...industry participation in the management and evaluation of crosscutting programs should be expanded...and crosscutting research should emphasize industry-specific work identified in industry roadmaps." The report also recognizes that there are inherent difficulties in defining crosscutting R&D solely from industry needs and says that, "...relying on 'market pull' to define R&D objectives has inherent drawbacks...and there is no simple, self-reinforcing mechanism for identifying promising crosscutting programs."

The IMF program addresses the National Research Council's recommendations for the Office to focus more attention on the industry-specific and crosscutting material needs of the *IOFs*, while at the same time maintaining support for core activities that have the backing of industry. The IMF program will become an integrated part of the *IOF* strategy to develop new products and equipment for energy efficiency, waste reduction, and productivity improvements in the *IOFs*.

Opportunities clearly exist to save energy, reduce life-cycle costs, and improve environmental performance through the adoption of improved industrial materials for manufacturing processes and equipment. While it is known that substantial benefits can be achieved through such factors as longer service life, reduced maintenance, and increased production, a comprehensive evaluation of the potential benefits of advanced industrial materials is needed. The IMF Program, in cooperation with the National Research Council, National Materials Advisory Board, is planning to proceed with this critical evaluation, taking into account the widespread application of materials in production processes throughout the industrial sector.

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<sup>2</sup> National Research Council. *Industrial Technology Assessment — An Evaluation of the Research Program of the Office of Industrial Technologies*. National Academy Press. 1999.

## 2. STRATEGIC ISSUES

Several strategic issues are considered key to ensuring an effective transition to a unified, successful industrial materials program within OIT. Among these are:

- the selection of materials technologies to be addressed
- the spectrum of research and development activities to be considered
- identification and prioritization of cross-cutting technology opportunities
- metrics for quantification of success or failure

### SELECTION OF MATERIALS TECHNOLOGIES

The selection of materials technologies to be addressed by the program will be driven by the industrial applications in which the materials will be used. Ceramics, composites, polymers, and alloys are among the general types of materials that are being investigated by various OIT programs for industrial applications. Unfortunately, it is often difficult to determine in advance which materials are more likely to have greater applicability and appeal to industry. The selection of materials for further RD&D can only be judged in terms of the industrial environments in which they apply. In fact, the only sound basis for materials development and selection is to match the requirements of the industrial environment with the physical properties of the candidate materials.

To facilitate the selection process, the IMF program must develop a thorough understanding of the industrial environments where advanced materials will be needed in terms of temperature, pressure, chemical species, and process flow rates, as well as fluctuations in these parameters over time. The performance attributes (e.g., fatigue, corrosion, and wear resistance; high-temperature strength; thermal and electric conductivity; emissivity; and thermal expansion) of individual materials will be evaluated for suitability in these environments. Materials for sensors and controls, for example, will have to exhibit all of the above performance characteristics plus demonstrate sensitivity, selectivity, durability, and cost effectiveness.

The program will incorporate the comprehensive information it obtains on the chemical and physical properties of advanced materials into databases that can be used to evaluate the degree of fit of specific materials in various industrial environments. Funding from directed activities will be used to develop these databases.

### SPECTRUM OF RESEARCH AND DEVELOPMENT ACTIVITIES

The federal government's traditional role of supporting R&D that the private sector will not undertake on its own because of high risk, lack of R&D capability, long lead time, or uncertain benefit is understood and accepted by industry. A spectrum of activities fall within the realm of federal R&D, depending on the national need and the degree of maturity of the technology. This spectrum includes

- basic research,
- applied research,
- development, and

- demonstration.

Within the Department of Energy, the Office of Science is the lead organization for conducting basic research, relying heavily on the scientific capabilities of universities and the national laboratories. The Office of Industrial Technologies funds applied research, development, and demonstration projects, primarily to address needs that have been identified by industry through the *IOF* process. The Office also monitors developments in basic research.

A sizeable gap exists, however, between the basic science efforts in physics and chemistry conducted by the Office of Science and the advanced materials R&D projects sponsored by OIT. The National Research Council, in its recent evaluation of the research activities of OIT, acknowledges this gap and recommends that the Office focus its efforts on the industry-specific and crosscutting technology needs of the *IOFs*. While the report advises OIT to address “market-pull” needs for advanced materials, it also points out the pitfalls of neglecting other types of activities. The Office will need to continue to support core research activities that enable it to take advantage of developments in basic science potentially beneficial to the *IOFs*. A key issue for the IMF program, therefore, is striking the proper balance between industry-specific, crosscutting, and core R&D projects within its portfolio.



### 3. PROGRAM MISSION, GOALS, STRATEGIES AND PERFORMANCE METRICS

#### MISSION

*The mission of the new IMF program is to lead a national effort to research, design, develop, engineer, and test new and improved materials for the IOFs.* Successful development of advanced materials will lead to improvements in energy efficiency, environmental performance, productivity, product quality, and global competitiveness in the IOFs. The program focuses on materials needs identified in the IOF visions and technology roadmaps, with emphasis on high-priority needs shared by two or more IOFs.

#### STRATEGY

The strategy of the IMF program for achieving its mission is to identify, support, and nurture promising efforts in materials and processing technologies to the point that they can be demonstrated in industrial applications. The scope of funded activities can cover proof of concept, applied research and development, and applications engineering. The IMF will continually strive to maintain a proper balance among projects with short, medium, and long term lead times and payoffs. Demonstrations are not a part of the strategy. Promising materials for components, subsystems, and integrated systems produced by the IMF program will be “turned over” for field testing and demonstration to the IOFs or crosscutting areas in which they apply. Ideally, the IMF Program will nurture the technologies to the point at which they can compete for funding by the IOF teams for field testing and demonstration to ensure that they will be implemented. It is important that the IOF teams be kept fully aware of the progress of projects in IMF and of the potential for applications in the specific industries.

A variety of activities will be undertaken, including the development of processing methods, characterizations of microstructures and thermophysical properties, analysis of life-cycle costs and benefits, and analysis of factors affecting environmental emissions. More specifically, the program will:

- C develop materials property/engineering databases for materials used in industrial applications;
- C develop advanced materials for manufacturing processes that will increase high temperature strength and fatigue resistance, increase corrosion resistance, and improve wear resistance in all of the IOFs;
- C develop functional and protective materials for sensors, actuators, and other devices in industrial environments; and
- C develop improved materials for refractories and other components of industrial furnaces, boilers, and gasifiers.

#### PERFORMANCE METRICS

The program will use metrics to track the progress of the program, with program reviews held annually. Metrics will be developed from the following categories:

- C impact of technology implementation as measured by the return on investment (i.e., value saved compared to baseline practices divided by the value of IMF investment)
- C estimated energy savings based on replacement of current materials and systems
- C extent that the technical milestones of the program have been met on schedule and within budget
- C number of technologies that successfully compete for funding by the *IOF* teams through the solicitation process
- C number of *IOFs* that are affected by the development of a new material
- C extent of collaboration with the *IOFs*, materials producers, universities, and other federal programs
- C level of leveraging from sources other than the Department of Energy and cost sharing from private industry

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## 4. R&D PLAN — FISCAL YEAR 2000 THROUGH 2004

Three types of R&D activities will be conducted by the IMF program:

- industry-specific,
- crosscutting technology, and
- knowledge base, or core activities.

Core activities will ensure the continued availability of new materials and processes. In addition to the above, a portion of the IMF budget each year will be used for directed activities.

**Industry-specific** activities consist of R&D in advanced materials directed toward the needs of *IOFs*. Highest priority will be given to materials needs that have been identified by more than one *IOF*. Many of the industry-specific needs for advanced industrial materials are currently being addressed through existing *IOF* solicitations. Industry-specific research and development projects will be supported from one to three years until the technologies are sufficiently mature to compete for *IOF* team funding. Cost share for these projects will be 50% over their duration.

**Crosscutting** activities consist of materials-related R&D that benefit crosscutting programs within OIT, specifically combustion and sensors and controls. For crosscutting R&D, the relevant crosscutting team and the IMF program will share technical assistance and leverage funding as needed to ensure success. Crosscutting research projects may be supported for one to five years. Cost share may be as low as 30% in the early stages, but will be 50% over the duration of the projects.

**Core** activities consist of R&D and supporting activities that provide the knowledge base and technical expertise to meet the advanced material needs of the *IOFs* for many years. Core activities will include support for projects that strengthen fundamental understanding of material physical and chemical properties, as well as processing methods for materials of interest to the *IOFs*. Core activity research projects may be supported for three to seven years, as appropriate.

**Directed** activities will be programmatic in nature and will include studies by independent organizations, workshops, review meetings, program planning and analysis, and evaluations. Funding will be used to support the Materials Processing User Center (MPlus) and other facilities as required to assist the *IOFs* in addressing short-term materials needs.

The relative mix of activities among these areas will be determined by OIT management. The mix will evolve over the transition period in response to needs that get identified as a result of the *IOF* process and new efforts in the development of crosscutting technologies. ***The initial targets are 50% funding for industry-specific and crosscutting, 35% funding for core activities, and 15% funding for directed activities.***

### TRANSITION TO A UNIFIED PROGRAM

The approach to achieve a unified program will involve a transition over the next four fiscal years. Beginning in fiscal year 2000, a comprehensive assessment of all existing materials-related projects

in the Office will be completed in order to determine the time and funding required to bring them to a successful conclusion. This assessment will be used for program planning through the transition period and will provide a starting point for a more comprehensive study by an independent organization to determine future directions and priorities for the IMF Program, based on a detailed examination of materials needs of the *IOFs*. The first stage will be completed by the end of the first quarter of FY 2001; the independent study may require a year or more.

While the primary intent of the assessment is to strengthen IMF linkages to the *IOF* process and crosscutting technologies, it will also define the scope of the *core* activities, determining potential directions and priorities of projects developing fundamental knowledge. Emphasis will also be on processing methods and evaluation of the potential for commercialization and benefits. As appropriate, the assessment will establish an orderly termination process for projects that 1) have met their objectives and have progressed to the final stages of commercialization, and/or 2) do not have sufficient industrial interest to support demonstration, process development, and/or scale-up.

**In fiscal year 2000**, approximately 89 percent of the funds will be used for completing existing efforts through existing contract or assistance mechanisms. The remaining 11 percent will be used to fund two competitive solicitations that will be aimed at the mission of the new IMF program. One of the solicitations will be focused on industry specific and crosscut elements of the program. The second solicitation will be open to the national laboratories and universities and will be aimed toward *core* areas.

**In fiscal year 2001**, approximately 60 percent of the funds will be used to complete existing projects through existing contract and assistance mechanisms. Another 25 percent will be used in a second round of competitive solicitations aimed toward the objectives of the new IMF program. Once again the solicitation will be split into two parts: one for industrial performers and one for the national laboratories and universities. Approximately 15 percent of the funds will be used for directed activities.

**In fiscal year 2002**, approximately 35 percent of the funds will be used to complete existing projects through existing mechanisms. Fifty percent will be used in competitive solicitations and continued support of projects selected in the prior two years. It is expected that all *core* activities will be led by national laboratories or universities. The relative funding mix among the three elements (industry specific, crosscut, and *core*) will be reviewed on an annual basis by OIT management. The remaining 15 percent of the funds will be used for directed activities.

**In fiscal year 2003**, about 10 percent of the funds will be used to complete existing projects through existing mechanisms. Approximately 75 percent will be used for new competitive solicitations and continued support of projects selected in prior years. The final 15 percent of the funds will be used for directed activities

**In fiscal year 2004**, 85 percent of the funds will be used for new competitive solicitations and continued support of projects selected in prior years. The remaining 15 percent will be used for directed activities.

## 5. PROGRAM MANAGEMENT PLAN

The IMF program will be managed by the Office of Industrial Technologies in the Office of Energy Efficiency and Renewable Energy. A number of other organizations will be involved in the implementation and coordination of the planned R&D activities.

Program management responsibilities include development and defense of the program's annual funding request to Congress, development and dissemination of programmatic guidance and technical directions, coordination with related programs, priority setting, procurements, monitoring and tracking of projects, and achievement of the program's milestones.

Program implementation will be handled primarily by the DOE Operations Offices. It is expected that industrial performers will play the lead roles in carrying out industry-specific materials and crosscutting R&D, with the national laboratories and universities playing supporting roles as members of the teams. National laboratories and universities, in cooperation with industrial partners, will play the lead roles in carrying out core activities.

Coordination with other offices in the Department, other federal agencies, and the various *IOF* teams is a critical program management function. Coordination with the *IOF* teams will occur on a routine basis, with the goal of leveraging resources as much as possible. Program representatives will participate in *IOF* vision and roadmap workshops and will contribute technical expertise in *IOF* planning sessions. The IMF program will monitor programs within the Department's Office of Science, the Department of Defense, the Department of Commerce's National Institute for Standards and Technology, the National Aeronautic and Space Administration, and the National Science Foundation to identify opportunities for further leveraging of resources.

Numerous industry organizations are involved in the development of advanced materials, including the United States Advanced Ceramics Association, the Metal Powder Industry Federation, ASM International, the Materials Technology Institute of the Chemicals Process Industries, the American Iron and Steel Institute, The Aluminum Association, and many others. The program will coordinate with these organizations through their ties to the *IOFs*.